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ADAPTIVE DUTY CYCLE AWARE BROADCASTING AND SCHEDULING IN WIRELESS SENSOR NETWORK

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Abstract- Duty cycling plays a significant role in reducing more energy consumption by the nodes which are working continuously. When the nodes dissipate energy in continuous manner leads to reduction in lifetime of the nodes and hence minimizes the overall performance ratio of the system.

In wireless sensor network, duty cycle is the ratio of active time or operational time i.e the time at which the particular set of nodes are active to the entire scheduling time. With duty cycling, each node oscillates between active and sleeping states so the nodes need not to be active or in continuous waiting period during its complete lifespan. The nodes are making active according to their requirements which saves energy.

In this paper, the concept of asynchronous duty cycle broadcasting (ADB) protocol is used in which nodes are wakeup asynchronously which reduces the packet loss, increase throughput, reduces delay and packet delivery loss, and hence increase the energy efficiency by using multihop unicasting and broadcasting scenario. Also, the congestion can be controlled by using unicasting and thus, the overall performance of the network can be improved. The proposed algorithm mentioned in this paper will make the system adaptive i.e.making the network edge smarter and self-aware, intuitively finding and retaining the best, most reliable pathways for network traffic.

Keywords: Duty Cycle, Multihop, Wireless Sensor Network, Scheduling, Sensor Node.

I. INTRODUCTION

- *Wireless Sensor Network and Duty Cycle*

A wireless sensor network consists of group of sensors, or node which are small in size, battery powered that are connected by a wireless medium designed to perform various tasks where sensation is the requirement. The sensors are having a fixed communication and sensing range, which can vary depending on the type of sensing performed. As the sensors are battery powered which is limited and costly, so the proper utilization of this scarce factor is the need of today. Sensor nodes are expected to operate autonomously in unconditional environments and comparatively in large numbers. Failures are very prone in wireless sensor networks due to hostile, unsteady environment and neglecting deployment. The data communication and various network operations cause energy diminution in sensor nodes and therefore, it is common for sensor nodes to exhaust its energy completely and stop operating properly or completely. This may cause connectivity and packet loss during communication in wireless network. Therefore, it is necessary that prior network failure detection should be done and appropriate measures should be taken to maintain network operation with fluency. Figure 1. shows the simple wireless sensor network .

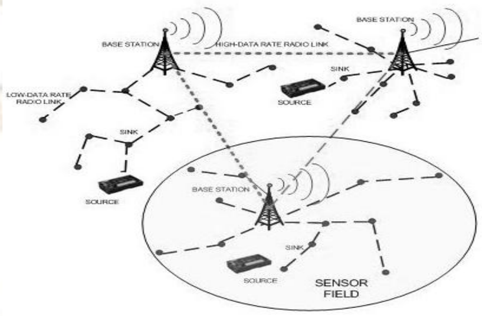


Figure 1. A Simple Wireless Sensor Network

A Sink node is similar to cluster head node which gather, control data collected by other neighboring sensor node. The sink may also be a mobile node acting as an information sink, or any other entity that is required to extract information from the sensor network. The multi-hop network can operate in both the sensor-to-sink or sink-to-sensor i.e broadcast or multi-cast nodes.

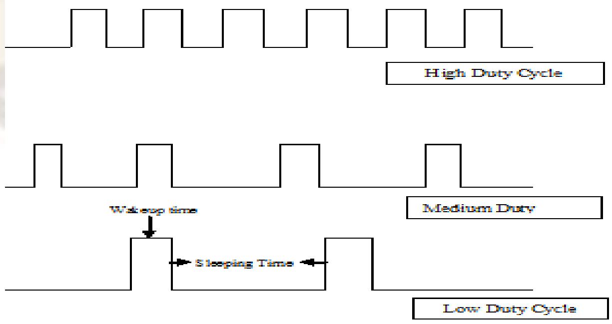


Figure 2. Various levels of Duty Cycle

Wireless sensor devices uses duty cycling in which each node oscillates between active and sleeping states so the nodes need not to be active or in continuous waiting period during its complete lifespan. The nodes are making active according to their requirements which saves energy. Nodes can also regulate data rate and transmission power to reduce energy consumption while maintaining the required link quality. Duty Cycle (DC) approaches can be grouped into: asynchronous Duty Cycle, synchronised or scheduled Duty Cycle and hybrid approaches.

Asynchronous duty cycling (ADC) is typified by Low Power Listening (LPL) and B-MAC . The radio is switch on for a very specific short amounts of time to check for channel activity known as channel polling. If activity is detected the radio will receive data, else it gets switch off. Transmitting nodes precede messages with a preamble longer than the sleep time of the recipient, to guarantee they will have turned their radios on, detected the channel activity and be ready to receive before the preamble is ended. This added the energy cost on the transmitter. Long preambles can also increase network congestion.

In a different approach, MH-MAC switches between asynchronous and synchronous modes of operation, therefore enabling contention during periods of lighter congestion and contention-free communications during periods of heavy network usage. Figure 2. shows the various levels of duty cycle. High duty cycle gives fast transmission and reception of packets but consumes more energy. In case of real time applications, overall implementation cost of the system is more and also have to compromise on various factors like battery which is very important factor in wsn.

In case of low duty cycle, the transmission and reception time of the packets will get increase which cause delays. The waiting period of the sender for getting acknowledgement from the receiver and the receiver for receiving the data packets will get increased.

In case of medium duty cycle, the nodes are switching asynchronously between active and sleeping states which leads to proper utilization of available and limited factors in wsn.

II. EXISTING ADB PROTOCOL

ADB (Asynchronous Duty-cycle Broadcasting) is the protocol for efficient multihop broadcast in wireless sensor networks using asynchronous duty-cycling. ADB differs from traditional multihop broadcast protocols that operate above the MAC layer, in that it is integrated with the MAC layer to exploit information only available at this layer. Rather than treating the data transmission from a node to all of its neighbors as the basic unit of progress for the multihop broadcast, ADB dynamically optimizes the broadcast at the level of transmission to each individual neighbor of a node, as the neighbours asynchronously wakeup[2].

In the example shown in figure 3, the network consists of three nodes, nodes *S*, *R1*, and *R2*, all within transmission ranges of each other. Node *S* wants to broadcast a DATA packet to all nodes. When *R1* wakes up, node *S* transmits the packet upon receiving *R1*'s beacon in the same way as for unicast in RI-MAC.

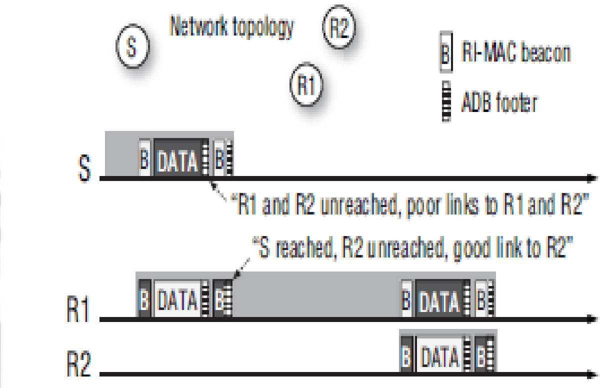


Figure 3. Overview of ADB Protocol

Figure 3 gives an overview of the operation of ADB. However, ADB includes a new "footer" in DATA frames and acknowledgment beacons (ACKs), indicating the progress of the broadcast, including some transmissions that are about to happen. A receiving node uses this information to avoid unnecessary transmissions and to decide whether it should forward the packet to a neighbor that has not received it[2].

In this example, the ADB footer in the DATA frame from *S* informs *R1* that *R2* has not been reached yet by the broadcast and that the quality of the link (*S*,*R2*) is poor. Suppose the quality of link (*R*1,*R2*) is good because of the short distance. Node *R1* decides to delivery the packet to *R2* and indicates the good quality of (*R*1,*R2*) in the footer of the ACK to *R1*. Upon receiving this ACK, *S* learns that it is better for *R1* to transmit the packet to *R2*, so *S* "*delegates*" handling of *R2* to *R1*. As *S* has no other neighbor to be reached, *S* then goes to sleep immediately. When *R2* wakes up, *R1* unicasts the DATA frame to *R2* in the same way, except that the ADB footer in the DATA frame indicates that *S* has received the DATA frame, allowing *R2* to sleep immediately because all neighbors of *R2* have been reached[2]. Figure3. shows an overview of ADB Protocol.

Features of ADB

- ADB allows a node to go to sleep once all its neighbours have been reached or been delegated to other nodes.
- ADB attempts to avoid transmissions over poor links.
- ADB delivers a broadcast packet without occupying the medium while waiting for each receiver to wake up, to allow a neighbor to start rebroadcasting the packet immediately.
- ADB informs a neighbor that has just waken up on the progress of a broadcast, to avoid unnecessary waiting and transmissions.

ADB is composed of two basic components: (i) *efficient* *encoding of ADB control information* which helps to distribute information on the progress of a broadcast and information for delegation decisions and (ii) the *delegation procedure*, which runs whenever a broadcast DATA packet or a beacon with an ADB footer is received or overheard, determining which nodes the DATA packet should be forwarded to and which nodes should be delegated[2].

III. SYSTEM SCENARIO WITH MODIFIED ADB PROTOCOL

Figure 4. shows the scenario of the implemented system with modification in existing ADB protocol. In this, sender node broadcast the data to all its neighbors within its communication range. Then, the sender node will get the information from all its neighbors. Now the sender is having all the required information about all its neighbors.

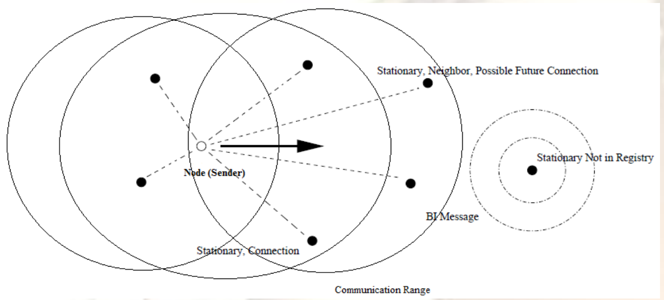


Figure 4. Scenario of Implemented System

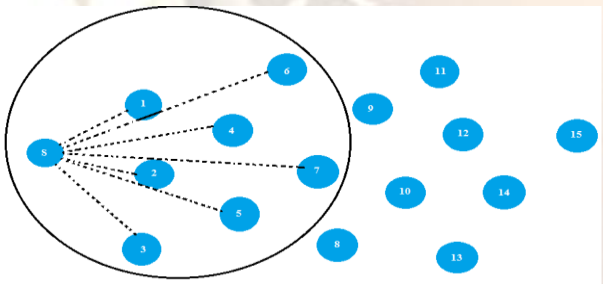


Figure 5. Source node S broadcasting within its communication range

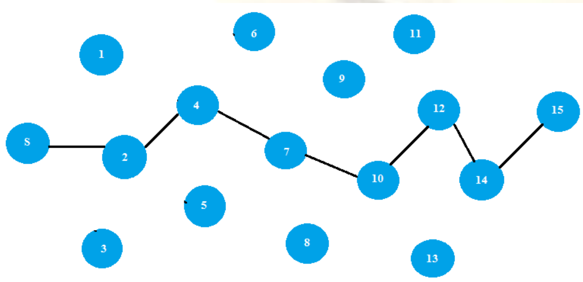


Figure 6. No. of nodes wake up in existing ADB protocol is 6.

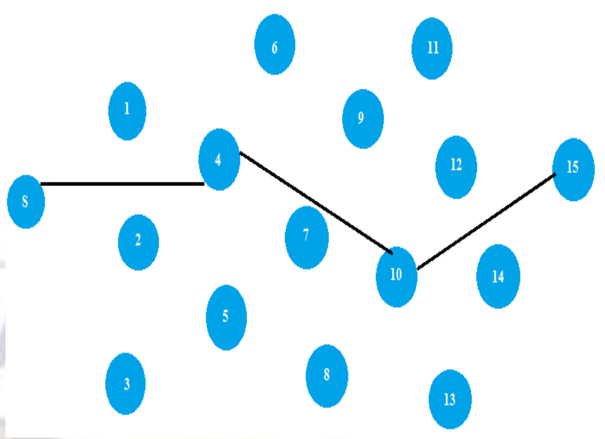


Figure 7. Project idea 1

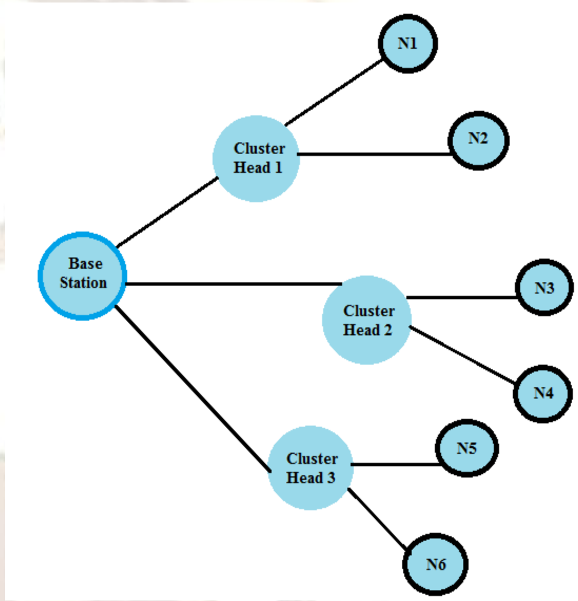
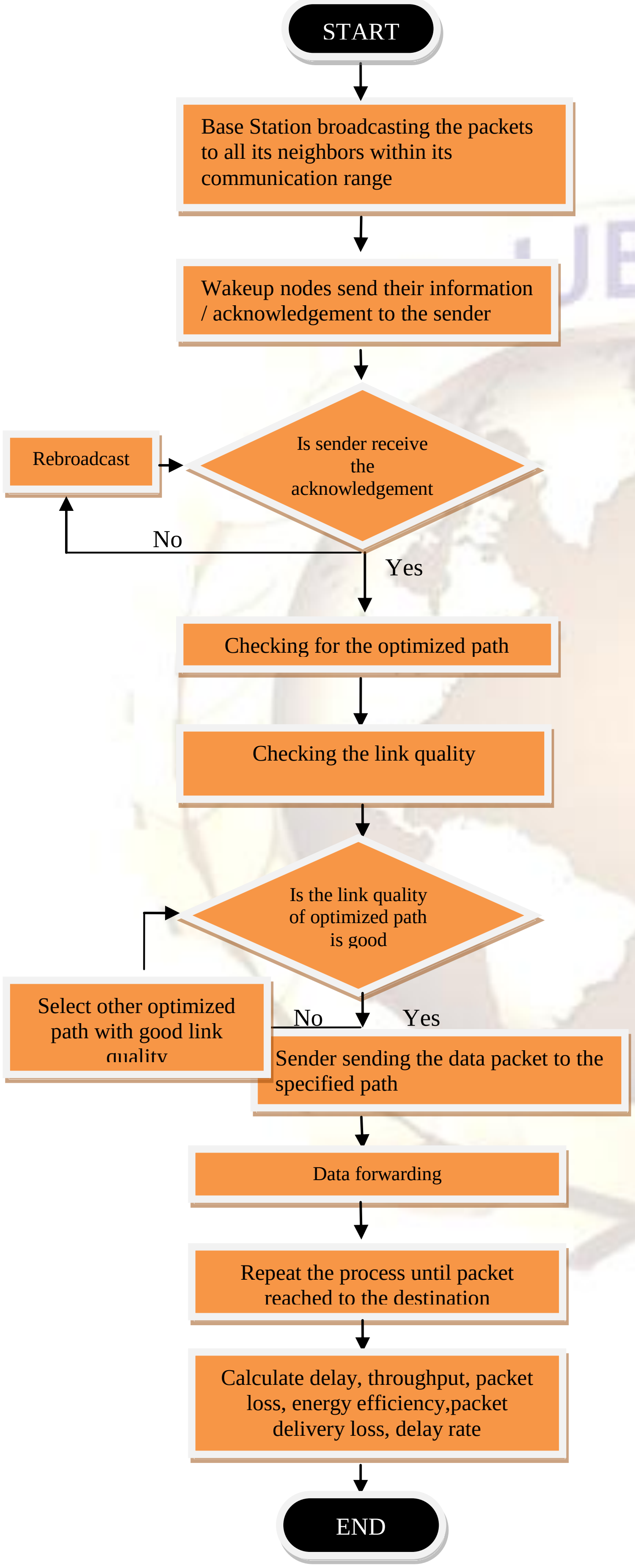


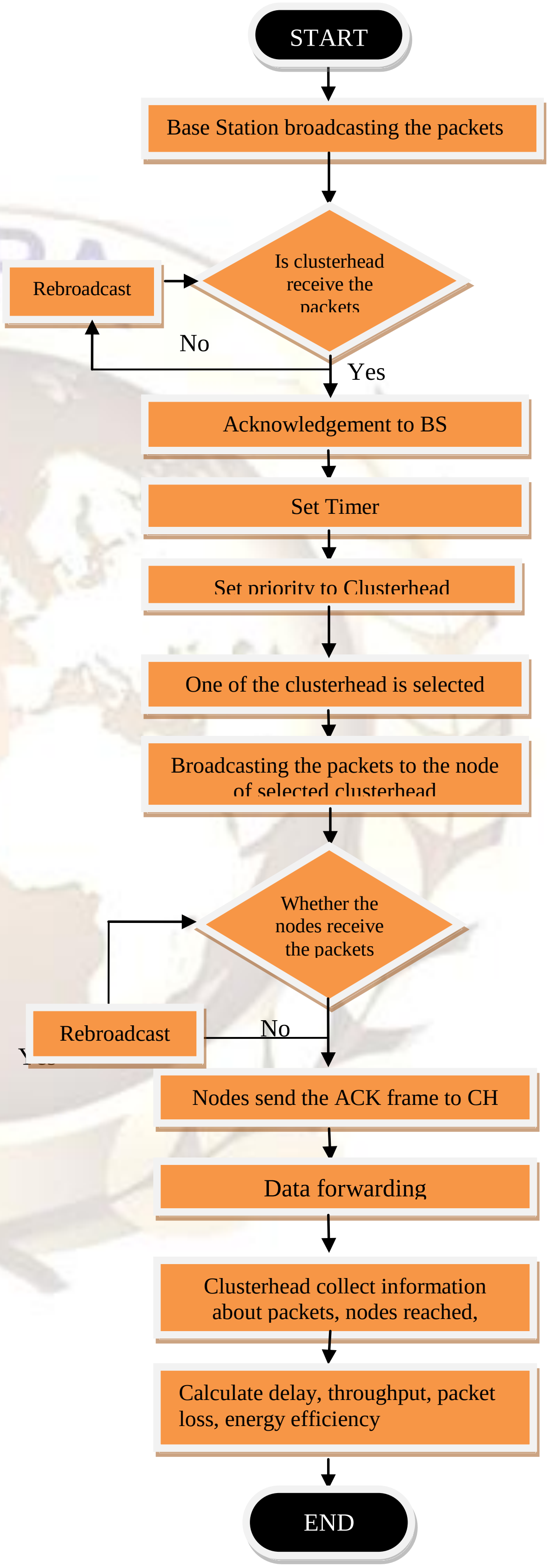
Figure 8. Project idea 2

As shown in figure 8. here, base station broadcasting the packets to all the cluster head 1, 2 and 3. The function of cluster head is to decide which node or path has to be followed for sending the packets to the destination. Also , the cluster head is the one who gather all the information from their respective nodes. It acts as an intermediate between the nodes and the base station for sending and reception of data packets.The cluster head will gather the information about the nodes. The priority should be given to each node according to the requirement which make it adaptive. Here, three different timers is implemented in cc file. Timers helps to avoid congestion. Figure 6. shows the proposed algorithm.

PROPOSED ALGORITHM 1 (Modified ADB protocol)



PROPOSED ALGORITHM 2 (ClusterHead Selection)



IV. SIMULATION RESULTS

- Outputs through NAM file using NS-2.34 (in graphical format)

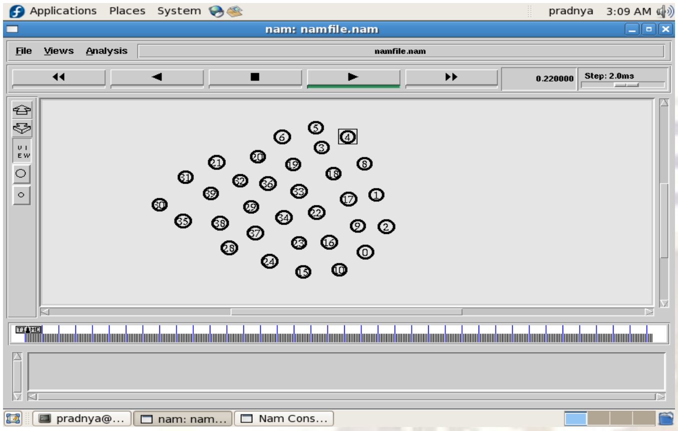


Figure 9. Showing the position of nodes on Network Animator

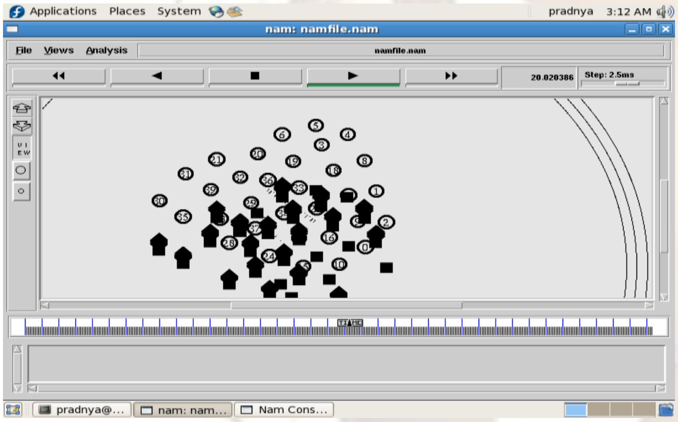


Figure 10. Showing the sending, reception, acknowledgement and packet drop

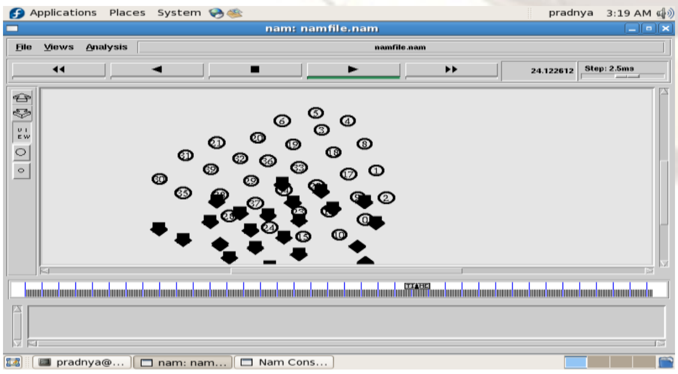
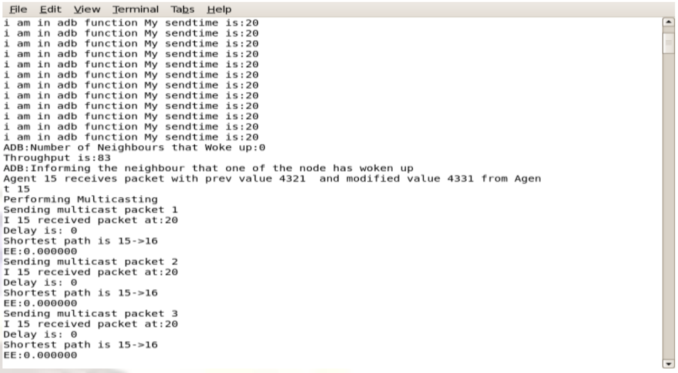


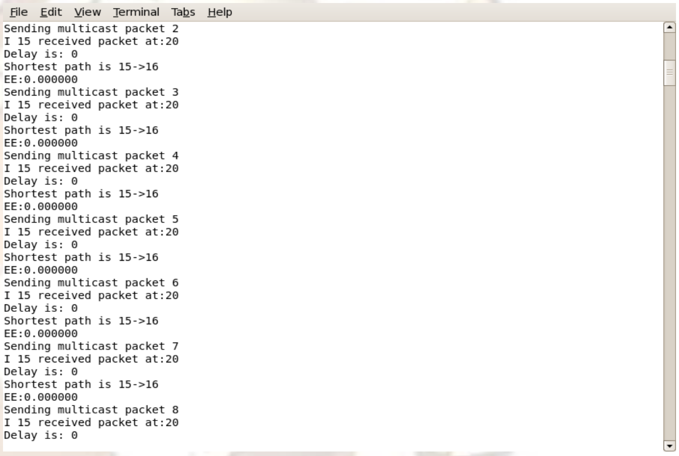
Figure 11. Showing the packet loss due to overflow of packets

- Output through CC file using NS-2.34 (in text format)



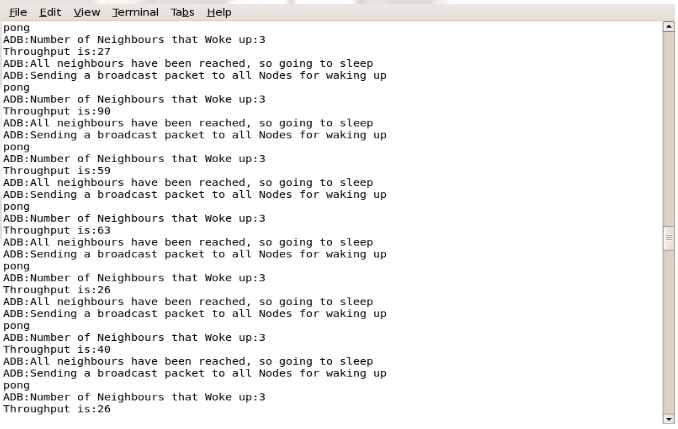
```
File Edit View Terminal Tabs Help
i am in adb function My sendtime is:20
i am in adb function My sendtime is:20
i am in adb function My sendtime is:20
i am in adb function My sendtime is:20
i am in adb function My sendtime is:20
i am in adb function My sendtime is:20
i am in adb function My sendtime is:20
i am in adb function My sendtime is:20
i am in adb function My sendtime is:20
i am in adb function My sendtime is:20
i am in adb function My sendtime is:20
i am in adb function My sendtime is:20
ADB:Number of Neighbours that Woke up:0
Throughput is:83
ADB:Informing the neighbour that one of the node has woken up
Agent 15 receives packet with prev value 4321  and modified value 4331 from Agen
t 15
Performing Multicasting
Sending multicast packet 1
I 15 received packet at:20
Delay is: 0
Shortest path is 15->16
EE:0.000000
Sending multicast packet 2
I 15 received packet at:20
Delay is: 0
Shortest path is 15->16
EE:0.000000
Sending multicast packet 3
I 15 received packet at:20
Delay is: 0
Shortest path is 15->16
EE:0.000000
```

Figure 12. Initially the sender sends the packets to all its neighbors within its communication range having sending time as 20.



```
File Edit View Terminal Tabs Help
Sending multicast packet 2
I 15 received packet at:20
Delay is: 0
Shortest path is 15->16
EE:0.000000
Sending multicast packet 3
I 15 received packet at:20
Delay is: 0
Shortest path is 15->16
EE:0.000000
Sending multicast packet 4
I 15 received packet at:20
Delay is: 0
Shortest path is 15->16
EE:0.000000
Sending multicast packet 5
I 15 received packet at:20
Delay is: 0
Shortest path is 15->16
EE:0.000000
Sending multicast packet 6
I 15 received packet at:20
Delay is: 0
Shortest path is 15->16
EE:0.000000
Sending multicast packet 7
I 15 received packet at:20
Delay is: 0
Shortest path is 15->16
EE:0.000000
Sending multicast packet 8
I 15 received packet at:20
Delay is: 0
```

Figure 13. Sender sending the multicast packets 2, 3,4,5,6,7 and 8.



```
File Edit View Terminal Tabs Help
pong
ADB:Number of Neighbours that Woke up:3
Throughput is:27
ADB:All neighbours have been reached, so going to sleep
ADB:Sending a broadcast packet to all Nodes for waking up
pong
ADB:Number of Neighbours that Woke up:3
Throughput is:90
ADB:All neighbours have been reached, so going to sleep
ADB:Sending a broadcast packet to all Nodes for waking up
pong
ADB:Number of Neighbours that Woke up:3
Throughput is:59
ADB:All neighbours have been reached, so going to sleep
ADB:Sending a broadcast packet to all Nodes for waking up
pong
ADB:Number of Neighbours that Woke up:3
Throughput is:63
ADB:All neighbours have been reached, so going to sleep
ADB:Sending a broadcast packet to all Nodes for waking up
pong
ADB:Number of Neighbours that Woke up:3
Throughput is:26
ADB:All neighbours have been reached, so going to sleep
ADB:Sending a broadcast packet to all Nodes for waking up
pong
ADB:Number of Neighbours that Woke up:3
Throughput is:40
ADB:All neighbours have been reached, so going to sleep
ADB:Sending a broadcast packet to all Nodes for waking up
pong
ADB:Number of Neighbours that Woke up:3
Throughput is:26
```

Figure 14. Scenario in which three nodes has woken up.

- Performance analysis through Graphs

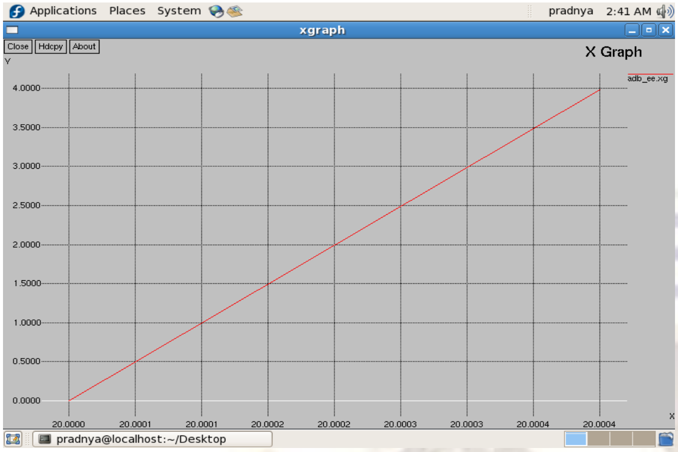


Figure 15. Graph showing energy efficiency using modified ADB protocol.

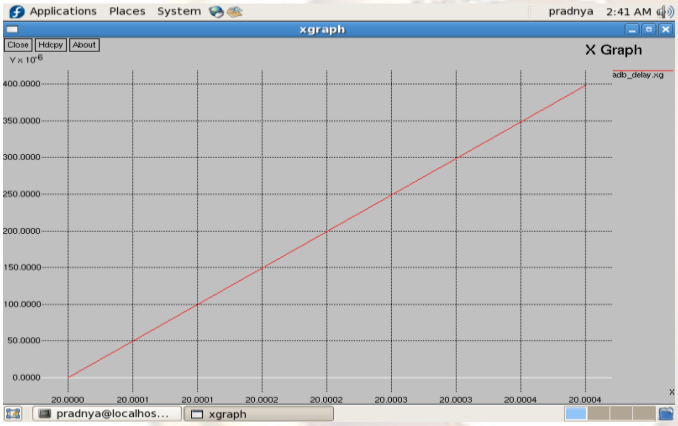


Figure 16. Graph showing delay using modified ADB protocol.

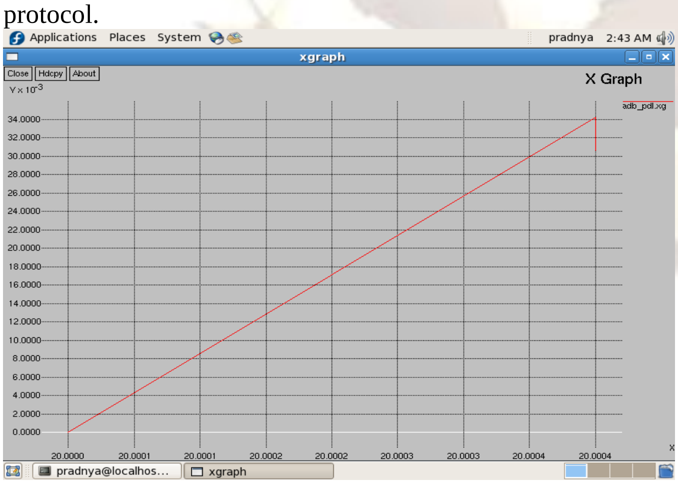


Figure 17. Graph showing packet delivery loss using modified ADB protocol.

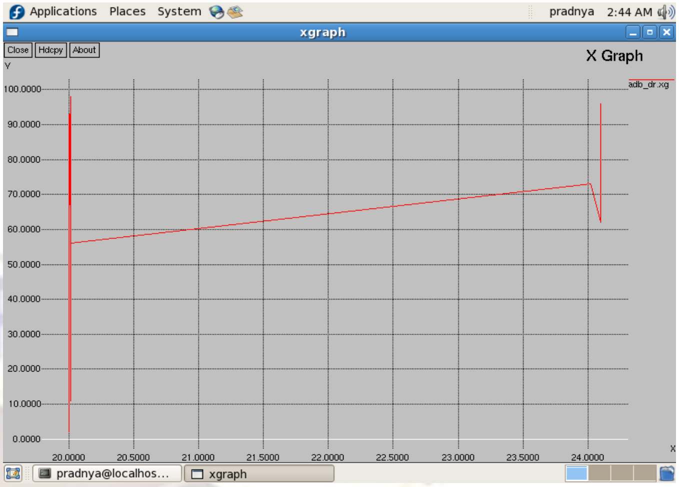


Figure 18. Graph showing delay ratio using modified ADB protocol.

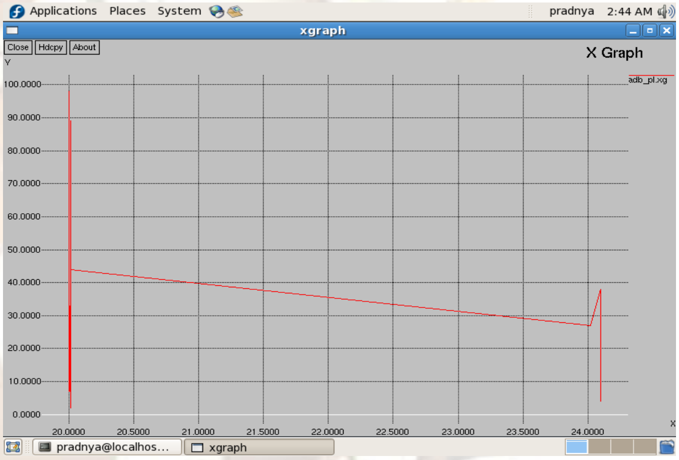


Figure 19. Graph showing packet loss using modified ADB protocol.

CONCLUSION

In this paper, the modification to the existing algorithm is performed. A as the nodes are wakeup asynchronously which reduces the packet loss, increase throughput, reduces delay and packet delivery loss, and hence increase the energy efficiency by using multihop unicasting and broadcasting scenario. Also, the congestion can be controlled by using unicasting and thus, the overall performance of the network can be improved. The proposed algorithm is selecting the optimized path which is having the more advantage over selecting the shortest path. Hence, enhance the feature of adaptivity.

FUTURE WORK

To make the proposed algorithm more adaptive, the new clusterhead selection algorithm is proposed in this paper. In this approach, the clusterheads are being selected dynamically from each clusters. These clusterheads is collecting all the information from their respective cluster and forwarding the data packets until the destination reached. To increase the performance, the more advanced algorithm will be used.

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